4th Quarter 2006 Progress Report

Reporting Period: July 1, 2006 – December 31, 2006

Experimental Assessment of Aggregate Surfacing Materials

MDT Project No. 8117-30, MSU Project No. 4W0839

Submitted by:

Dr. Bob Mokwa, Ph.D., P.E.
Assistant Professor
Department of Civil Engineering
College of Engineering
Montana State University – Bozeman

Mr. Eli Cuelho, P.E.
Research Engineer
Western Transportation Institute (WTI)
College of Engineering
Montana State University – Bozeman

Submitted to:

Montana Department of Transportation
Research Programs
2701 Prospect Avenue
Helena, Montana 59620

January 3, 2007

Task 1: Project Management/Administration

Project work was initiated on January 11, 2006 with an internal kick-off meeting at Montana State University (MSU) to review the project tasks and goals, and to discuss the types and quantities of aggregates that would be necessary to conduct the suite of proposed laboratory tests. Project activities during the first two quarters of the year were summarized in quarterly progress reports submitted in April and July 2006. This report summarizes project activities during the 3rd and 4th quarters of 2006 (July 1 through December 31).

During this period, Dr. Mokwa and Mr. Cuelho oversaw the various tasks associated with the project through frequent meetings with one another and the project graduate research assistant (Nick Trimble).

Task 2: Laboratory Testing

As discussed below, laboratory testing continued on the following three standard aggregate types:

1. CBC Type A Grade 5 – designated in this project as CBC 5A-1 through CBC 5A-3,
2. CBC Type A Grade 6 – designated in this project as: CBC 6A-1 through CBC 6A-6, and
3. CTS Type A Grade 2 – designated in this project as CTS 2A-1 through CTS 2A-5.

Working in conjunction with personnel from the MDT Materials Department, requests were sent to MDT District offices to obtain the relatively large aggregate samples (400 to 500 lb each) that are necessary to conduct the lab tests. Based on conversations that we have had with Matt Strizich, the distribution of test samples has been changed from the original plan. Based on the revised test plan, we have now received all of the 14 sample types necessary to complete the testing program, as shown in Table 1. We greatly appreciate the assistance provided by MDT personnel in obtaining and delivering these samples. The updated sample distribution plan is as follows:

- 6 – CBC 6A samples,
- 3 – CBC 5A samples, and
- 5 – CTS 2A samples.

Table 1 includes a summary of the sample origins, designations, locations and other relevant information that was included on the data sheets transmitted with the samples.

Table 2 summarizes the laboratory testing program and shows the quantity of tests completed as of December 31, 2006. This table will be continually updated during the study as a means of charting the progress of laboratory testing. Updated versions of the table will be

provided in subsequent progress reports. In summary, laboratory related activities conducted during this quarter include:

- Maximum and minimum void ratio testing has been completed, as shown in Table 2.
- The large 10-in-diameter permeameters were set up and calibrated. A method of consistently compacting samples was developed. Numerous trials were conducted to establish equipment and procedural controls. One permeability test was conducted on each aggregate.

A literature search is underway to document similar permeability and shear strength studies that have been conducted on aggregates or base course materials. Based on trial test runs, supplemented by information from the literature review, several modifications have been made to the permeability testing equipment and several different methods of compacting materials have been attempted to achieve the most repeatable and consistent test procedures.

For example, the permeameters were modified by lining the inside surface of the test cylinders with a 1/8-inch-thick neoprene rubber membrane. The membrane reduces seepage and hydraulic gradient edge effects, and minimizes migration of fine particles along the cylinder-soil interface.

A consistent method of compacting specimens inside the permeameter mold was also developed this quarter. After experimenting with numerous methods and approaches, it was determined that maintaining a consistent compaction effort was most important to provide equivalent permeability comparisons between the different aggregates. The method that we are currently using to compact permeability samples incorporates a Modified Proctor hammer (15 lb hammer, 18 inch drop) with a controlled number of drops. Twenty-five hammer drops per soil layer is used over the course of five layers. The relative density of each sample is measured and reported to provide additional information regarding compaction characteristics of the different aggregates.

Action Items for Next Quarter:

* Continue laboratory testing with a focus on finishing the permeability tests.
* Analyze/synthesize results from completed testing and begin write-up for final report.
* Examine and review published literature to develop an x-ray computed tomography procedure for examining and comparing pore space and pore size distributions of the different aggregates.

Task 3: Analyze and Synthesize Results

Data from laboratory tests are entered into spreadsheets and processed concurrently with the experimental work. Computed results are reviewed immediately for reasonableness. Some data analysis has been carried out and more background reading is being completed to gain more insight into how to organize, present, and analyze data. A synthesis of the results is in the early stages of development and will be a priority next quarter.

Action Items for Next Quarter:

* Continue organizing and processing laboratory data.
* Begin synthesizing and comparing test results from different aggregate samples.

Task 4: Report

Quarterly Progress Reports

Action Items for Next Quarter:

* Produce the progress report for the first quarter of 2007, encompassing the period from January through March 2007.

Final Report

Work on the final report will be initiated during the next quarter.

TABLE 1. Sample Descriptions

Aggregate Type	MDT District	Borrow Name or Owner	Nearest Town	County	Section Location	*Approx. Amount	Date Received	Comments
CBC 6A-1	Great Falls	John Haynes	Great Falls	Pondera	S½: S3-T28N-R7W	8 bags	2/14/06	
CBC 6A-2	Billings	Empire S&G (Wilson Pit)	Billings	Yellowstone	E½: S6-T1N-R27E	8 bags	2/14/06	
CBC 6A-3	Glendive	BLM	Miles City	Dawson	NW¼, SE¼: S9-T15N-R48E	8 bags	2/14/06	North of Terry, MT
CBC 6A-4	Missoula	Richardson, Collin	Thompson Falls	Sanders	Tract 6&7: S14-T21N-R29W	6 bags	2/14/06	Weeksville-West
CBC 6A-5	Butte	Neil Hazel	Toston	Broadwater	SW¼: S23-T5N-R2E	8 bags	3/15/06	US 287 So. of Toston. Project # NH8-4(41)93
CBC 6A-6	Kalispell	Sandon Const.	Kalispell	Flathead	SW1/4: S36-T30N-R21W	8 bags	2/14/06	Commercial source
CBC 5A-1	Great Falls	Helena S&G	Helena	Lewis and Clark	SE¼, SW¼: S23-T10N-R3W	8 bags	2/14/06	
CBC 5A-2	Missoula	G. Ruffato	Stevensville	Ravalli	W1/2, NE1/4: S23-T11N-R20W	6 bags	2/14/06	North of Stevensville Wye-Florence
CBC 5A-3	Kalispell	JTL-Hodson Pit	Kalispell	Flathead	W1/2, NE1/4 & SW1/4, NE1/4: S23-T30N-T21W	8 bags	3/15/06	Local commercial source
CTS 2A-1	Havre	Peterson Pit	Devon	Toole	SW¼, NW ¼: S23-T30N-R2E	8 bags	2/14/06	
CTS 2A-2	Glendive	Fisher S&G	Glendive	Dawson	SW¼: S34-T16N-R54E	8 bags	2/14/06	
CTS 2A-3	Missoula	JTL	Missoula	Missoula	E1/2, SE1/4: S6-T13N-R19W	6 bags	2/14/06	
CTS 2A-4	Lewistown	Brevig Land & Live	Lewistown	Fergus	NW¼, SW¼: S21-T16N-R17E	8 bags	3/15/06	Casino Creek Concrete
CTS 2A-5	Billings	JTL	Billings	Yellowstone	SE¼, S½: S15-T1S-R25E	8 bags	3/15/06	

*Note: One bag ≅ 40 to 60 lb of material.

TABLE 2. Laboratory Testing Program Summary

Aggregate Type	Gradation	L.A. Abrasion	Modified Proctor	Direct Shear	Max/Min Voids	Permeability
(No. of tests to be performed)	(1)	(1)	(1)	(3)	(1)	(3)
CBC 6A-1	1	1	*	3	1	2
CBC 6A-2	1	1	*	3	1	1
CBC 6A-3	1	1	*	3	1	1
CBC 6A-4	1	1	1	3	1	1
CBC 6A-5	1	1	*	3	1	1
CBC 6A-6	1	1	*	3	1	1
CBC 5A-1	1	1	*	3	1	1
CBC 5A-2	1	1	*	3	1	1
CBC 5A-3	1	1	*	3	1	1
CTS 2A-1	1	1	1	3	1	1
CTS 2A-2	1	1	1	3	1	1
CTS 2A-3	1	1	1	3	1	1
CTS 2A-4	1	1	1	3	1	1
CTS 2A-5	1	1	1	3	1	1

Note: This table provides an accounting of the number of tests conducted to date. A "*" indicates the test has been removed from the testing program.

Summary of Expenditures

Table 3 summarizes the expenditures on this project through December 31, 2006. Total dollar expenditures for the project through December 31, 2006 were $37,500.53, leaving $5,167.47 for the remainder of the project.

TABLE 3. Budget Summary

Budget Category	Budgeted Funds	Spent Quarter 3	Spent Quarter 4	Total Spent	Total Remaining
Salaries	$17,848.00	$7,723.85	$435.64	$16,097.70	$1,750.30
Benefits	$4,628.00	$1,525.77	$131.75	$3,266.21	$1,361.79
In-State Travel	$150.00	$0.00	$0.00	$0.00	$150.00
Out-of-State Travel	$0.00	$0.00	$0.00	$0.00	$0.00
Expendable Supplies	$200.00	$53.71	$78.40	$314.62	($114.62)
Tuition	$0.00	$0.00	$0.00	$0.00	$0.00
Subcontracts	$0.00	$0.00	$0.00	$0.00	$0.00
MDT Direct Costs	$22,826.00	$9,303.33	$645.79	$19,678.53	$3,147.47
Overhead	$4,566.00	$1,860.70	$129.15	$3,935.75	$630.25
MDT Share	$27,392.00	$11,164.03	$774.94	$23,614.28	$3,777.72
WTI/MSU Share	$15,276.00	$3,655.87	$2,130.38	$13,886.25	$1,389.75
Total	$42,668.00	$14,819.90	$2,905.32	$37,500.53	$5,167.47

Project Schedule Summary

An updated summary of the project schedule is shown in Figure 1. Approximately 85% of the remaining work will be conducted by the graduate research assistant. The graduate student's remaining salary on this project will be paid from other sources (a graduate fellowship) and will not impact the project budget. The remaining funds in the budget primarily will cover principal investigator labor for project oversight/management and final report preparation. In summary, the project is generally on schedule and the budget is on track with anticipated forecasts.

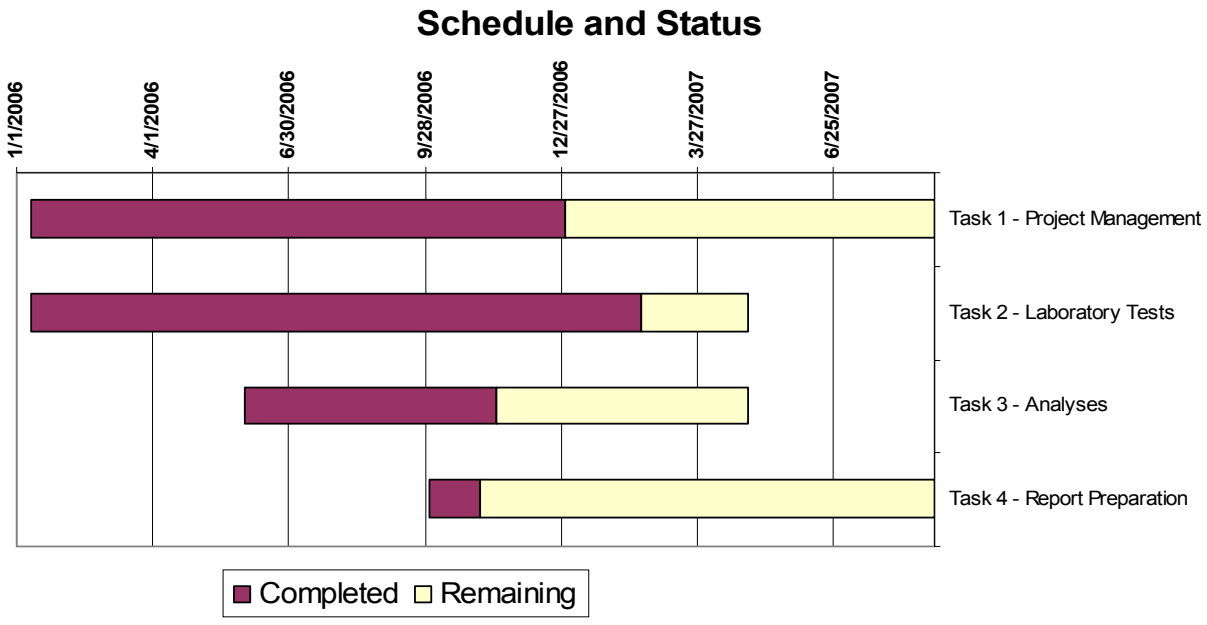

FIGURE 1. Project schedule summary.